SERDP & ESTCP Announce 2016 Projects of the Year

Notable Efforts Include Research on Management of Munition Constituent Contamination

THE STRATEGIC ENVIRONMENTAL Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP) have selected nine "Projects of the Year" in recognition of outstanding research and technology developments that will benefit the Department of Defense (DoD). These efforts are helping DoD enhance its mission capabilities, improve its environmental performance and reduce costs. The following are recipients of this honor and descriptions of their award-winning projects. Additional information is available at www.serdp-estcp.org.

Energy and Water
ESTCP Project of the Year

Zinc Bromide Flow Battery Installation for Islanding and Backup Power

Mr. Ryan Faries
Raytheon

DoD is the largest single consumer of energy in the United States. It operates over 500,000 buildings and structures with diverse inventory encompassing barracks, commissaries, data centers, office buildings, laboratories and aircraft maintenance facilities. A majority of these bases are largely dependent on a commercial power grid that is vulnerable to disruption from cyber-attacks, aging infrastructure, weather-related events and direct attack.

Mr. Ryan Faries from Raytheon along with his team demonstrated that microgrids with low cost, large-scale energy storage systems (ESS) have the potential to enhance energy security on military installations. This was done by facilitating integration of more renewable energy and reducing single-point-of-failure vulnerabilities associated with tradition electric service and back-up generators. This project was conducted at Marine Corps Air Station (MCAS) Miramar.

The project involved integrating the advanced Zinc-Bromide Battery and Intelligent Power and Energy Management microgrid control technologies with the infrastructure at MCAS Miramar to provide energy security, islanding capability and reduced costs. The demonstration connected MCAS Miramar's Department of Public Works (DPW) building to the ESS and solar photovoltaic (PV) system, enabling the building to receive power while disconnected (or "islanded") from the grid.

The goal of the project was to peak shave and island the building circuit for 72 hours under controlled loads. The islanding duration was directly related to three main factors:

1. Battery energy capacity
2. PV system generation (solar resource)
3. Load reduction.

For demonstrating the islanding capability, the project simulated commercial power grid interruption and powered the building by PV and storage. The monitoring and control system controlled the ESS and collected the power usage data. Data were then analyzed to determine if building loads were met during operational day scenarios.

The Raytheon team demonstrated that microgrids with low cost, large-scale ESS have the potential to enhance energy security on military installations.

The project successfully demonstrated the microgrid controller's ability to integrate and control the ESS, PV system and facility loads while connected to and islanded from the grid. The technology was able to manually increase and decrease the building load by more than 50 percent during islanding and the ESS was able to store energy during off peak time and discharge about 100 kilowatts of energy during peak time for close to three hours. While the demonstration did not meet the success criteria for the islanding duration, the system was able to power the DPW building from the PV array and ESS alone for over five hours and at its peak output, the PV array provided over 75 percent of the power to the facility.

Environmental Restoration ESTCP Project of the Year

Passive Biobarrier for Treating Co-Mingled Perchlorate and RDX in Groundwater at an Active Range

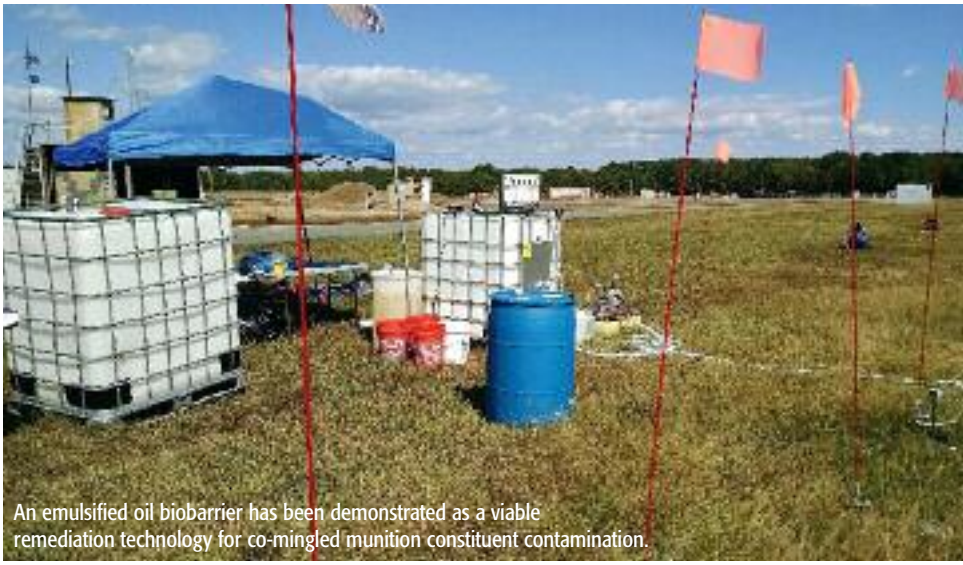
Dr. Paul B. Hatzinger
CB&I Federal Services

Perchlorate, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) are common and often co-mingled contaminants in soils and groundwater at military ranges worldwide. While in situ biodegradation of RDX, HMX and perchlorate individually have been demonstrated, remediation of co-mingled plumes has not been reported.

Dr. Paul Hatzinger from CB&I and his team led an ESTCP-funded project that aimed to investigate the feasibility of using a passive emulsified oil biobarrier to remediate co-mingled perchlorate, RDX and HMX at a contaminated site while minimizing impact to ongoing range activities.

The study results suggest that an emulsified oil biobarrier is a viable alternative to reduce the migration of co-mingled perchlorate and explosives in groundwater at sites similar to the trial site at the Naval Surface Warfare Center in Dahlgren, Virginia. Optimal areas for application of this technology include open burn/open detonation sites, munitions test ranges, explosive ordnance disposal training areas, target areas, munitions disposal sites and other regions where high concentrations of munitions constituents are likely to occur.

This remediation technology proves to be a passive and sustainable method with no requirements for operation or



An emulsified oil biobarrier has been demonstrated as a viable remediation technology for co-mingled munition constituent contamination.

maintenance other than injection and reinjection of the oil substrate. The approach also results in no impact to ongoing range activities at operational DoD ranges.

Environmental Restoration ESTCP Project of the Year

Demonstration of In Situ Treatment with Reactive Amendments for Contaminated Sediments in Active DoD Harbors

Dr. Bart Chadwick and Ms. Victoria Kirtay
Space and Naval Warfare Systems Command, Systems Center Pacific (SSC Pacific)

Successful delivery, placement and effectiveness of in situ treatment materials in active harbors has the potential to reduce costs, shorten recovery times and provide more effective alternatives to traditional methods of remediation for a wide range of sites with contaminated sediments. Traditional remediation of sediments has involved removal by dredging or isolation by capping. Removal actions may cause increased mobility and bioavailability of contaminated sediments, while physical capping may not be practical in active harbors and navigable waterways.

This project team successfully demonstrated in situ remediation of surface sediment at PSNS & IMF in Puget Sound.
MCS Apprentice William Blees

Dr. Bart Chadwick and Ms. Victoria Kirtay from SSC Pacific led an ESTCP-funded project to demonstrate and validate the placement, stability and performance of reactive amendments for treatment of contaminated sediments in active DoD harbor settings.

The team successfully demonstrated in situ remediation of surface sediment contaminated with hydrophobic organic compounds by placing a reactive amendment consisting of powdered activated carbon (PAC). This was done at a site contaminated with polychlorinated biphenyls (PCB) located at the Puget Sound Naval Shipyard & Intermediate Maintenance Facility (PSNS & IMF) in Washington State. The PAC was successfully placed on the seafloor of a half-acre target site to sorb PCBs in sediments, thereby reducing bioavailability and limiting bioaccumulation of contaminants into the tissues of benthic invertebrates and subsequently the food web.

Prior to this project, the majority of in situ sediment amendment efforts have been small, pilot-scale efforts in areas without significant limitations to access and generally targeted to low velocity waters with minimal vessel traffic or harbor activities. This project achieved the key goal of extending pilot-scale efforts to larger scale footprints in active DoD harbor areas with the additional challenge of remediation in deep water with high vessel traffic.

Resource Conservation and Resiliency ESTCP Project of the Year

Demonstration and Implementation of Autonomous Aerial Acoustic Recording Systems to Inventory DoD Installation Impact Areas for Threatened, Endangered and Species at Risk Bird Populations

Dr. David A. Buehler
University of Tennessee

Dr. Richard A. Fischer
U.S. Army Engineer Research and Development Center

DoD manages millions of acres of land that are used for training and testing to ensure military readiness. These lands are unique in that large and inaccessible

parcels have been set aside as impact areas for various types of munitions and explosive ordnance. These areas are also highly suitable as habitat for many threatened, endangered and at-risk (TER-S) avian species across the country. DoD has responsibility to monitor for and manage these species, which has proven difficult due to the inability to access these restricted areas on the ground.


The AAARS used to identify and characterize TER-S avian species in inaccessible locations.

An ESTCP-funded project led by Dr. Richard Fischer of the U.S. Army Engineer Research and Development Center and Dr. Dave Buehler at the University of Tennessee aimed to assess the significance of inaccessible areas to TER-S bird populations. They have addressed the accessibility issue by using an autonomous aerial acoustic recording system (AAARS) composed of a weather balloon that transports an electronic payload over otherwise unreachable areas. The key functions of the payload are to record the vocalizations of the target avian species, provide tracking telemetry to spatially correlate the audio data, track the flight path of the system, control the altitude of the system and reliably and safely recover the system.

The benefits of this effort are widespread and will have a broad impact on the DoD community. Implementation of the AAARS will enable natural resources staff for the first time to inventory which species are present in inaccessible areas, estimate relative abundance and density of these species and track the status of the populations over time. This project will provide information that will significantly improve DoD's ability to comply with the Migratory Bird Treaty Act, National Environmental Policy Act, Executive Order 13186, the Endangered Species Act and, where applicable, the Migratory Bird Rule. Furthermore, monitoring TER-S in formerly inaccessible areas will directly support the objectives of the recent DoD Coordinated Bird Monitoring Plan that recommends focused monitoring on species that have the potential for future impacts to the military mission.

Weapons Systems and Platforms ESTCP Project of the Year

Comprehensive Evaluation and Transition of Non-Chromated Paint Primers

Ms. Julia Russell
Ms. Brenna Skelley
Naval Air Warfare Center—Aircraft Division
(Patuxent River, Maryland)

Hexavalent chromium (chromate or Cr + 6) is the key component for high performance corrosion inhibiting primers used across DoD weapons systems and platforms. This known carcinogen has been targeted by DoD for reduction since 2009, which resulted in a need to identify, test, validate and implement alternative technologies. Ms. Julia Russell, Ms. Brenna Skelley and their team from the Naval Air Warfare Center—Aircraft Division in Patuxent River, Maryland have developed a comprehensive evaluation protocol for development and application of non-chromate primers.

Since this project was conceived in 2011, the Naval Air Systems Command has led a joint service effort, focused on alternative materials performance across the wide-range of corrosive environments to protect both surfaces and interfaces. The team evaluated technically and commercially mature commercial-off-the-shelf products for large scale primer usage. Other lower technology-readiness-level non-chromate primer technologies also were investigated for their potential as chromate coating replacements. These coatings were demonstrated on operational military aircraft.

Non-chromate primers have been authorized for use on the H-53 Sea Stallion as a result of this ESTCP-sponsored effort.
MCS2 Gary Granger Jr.

As a result of this effort, DoD has authorized reliable Type-I non-chromate primers on the outer mold line of various aircraft including the P-3 Orion, MQ-8 Fire Scout, F-15 Eagle, F-16 Fighting Falcon, UH-60 Black Hawk, E-2C Hawkeye, C-2 Greyhound, H-53 Helicopter and all Navy trainers. Multiple government and industry partners have each shown interest toward the adoption and implementation of non-chromate primers, reducing overall Cr + 6 use and likely elimination from some platforms and user facilities.

This effort demonstrated a method for evaluating both existing and future coatings to characterize the full range of their properties and determine their usefulness across all necessary applications. The outcome will provide the readiness of a given product for implementation or demonstration and validation, or recognize if additional investment is needed for optimization or concept development. Relative capability and maturity ranking will identify both the best state of the art for non chromate primers and technology gaps or requirement hurdles for developmental materials. A further benefit will be a final determination of those products that do not offer acceptable performance as a general chromate primer replacement, as well as those products that may only be acceptable for specific or limited applications based on reduced properties.

Environmental Restoration SERDP Project of the Year

Tracking the Uptake, Translocation, Cycling and Metabolism of Munitions Compounds in Coastal Marine Ecosystems Using Stable Isotopic Tracer

Dr. Craig R. Tobias
University of Connecticut

The explosives 2,4,6-trinitrotoluene (TNT) and RDX are common munitions constituents. Both compounds and their derivatives are U.S. Environmental Protection Agency (EPA) priority pollutants and are persistent in the environment. Within the contiguous 48 United States, there are approximately 41 active DoD installations located within the coastal zone. Exposure of marine/estuarine ecosystems at some sites is well documented, while other installations have a high potential for exposure but limited data on RDX or TNT concentrations in marine receptors. Coastal habitats are highly productive, nitrogen-limited and economically valuable ecosystems. Their response to munitions compounds and their effect on munitions cycling, persistence, bioaccumulation and mineralization are largely unknown.

Tidal wetting and drying of marsh plants was simulated in experimental tanks.

Dr. Craig Tobias from the University of Connecticut and his team led a SERDP-funded project that quantified the pathways and rates of RDX and TNT processing at three typical coastal ecotypes—subtidal vegetated, subtidal unvegetated and intertidal salt marsh. The team sought to understand the uptake rates of these compounds at the organismal to ecosystem scales, and which ecosystem components are important regulators of processing. In addition, the team investigated which ecosystem components act as zones of storage for munitions compounds versus those that promote metabolism, and whether ecosystem characteristics relate to processing or accumulation of munitions compounds. Finally, the team determined the extent which these compounds were mineralized to inert inorganic end products.

Study results have shown that TNT and RDX are processed in all ecotypes, and that while TNT loss is uniform across all sediment types, RDX loss is a function of organic matter content and redox conditions. The results also demonstrated that these parent munitions compounds and primary common derivatives are unlikely to persist in marine environments. The data from this study will provide a quantitative assessment of marine habitats as bioaccumulators or natural attenuators of munitions compounds.

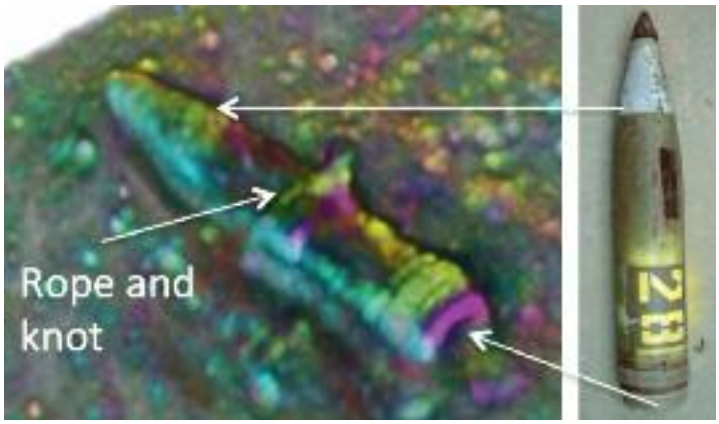
Munitions Response SERDP Project of the Year

Multi-pass and Non-concentric Target Circular Synthetic Aperture Sonar

Dr. Jermaine L. Kennedy
Naval Surface Warfare Center
Panama City Division

Dr. Timothy M. Marston
University of Washington
Applied Physics Laboratory

Circular Synthetic Aperture Sonar (CSAS) is a promising technique to classify and identify underwater objects, such as submerged or buried unexploded ordnance (UXO). It is easy to imagine CSAS being used to develop local training data to support acoustic surveys of the more than 400 Formerly Used Defense Sites that are potentially contaminated with submerged unexploded munitions. In the case of particularly high-value targets this technique may even be used for the survey. Dr. Jermaine Kennedy from the Naval Surface Warfare Center, Panama City Division and Dr. Timothy Marston from the University of Washington, Applied Physics Laboratory developed sophisticated sonar processing algorithms to produce acoustic images and thereby advance the usability of CSAS.



The CSAS technology is capable of producing detailed images using relatively low frequency underwater sound waves.

Sonar data was obtained from sample munitions and other objects in a variety of environments, ranging from flat and sandy seabed, to areas comprised primarily of rock, coral and complex limestone formations. These data were collected from an Autonomous Underwater Vehicle (AUV) instrumented with a dual-band sonar having a high frequency band in the hundreds of kilohertz (kHz) and a low frequency band in the tens of kHz. The sonar heads travelled along circular paths at different heights around each object. The researchers wrote software to estimate the three-dimensional (3D) position of the sonar head

using the sonar data itself, and developed new algorithms for coherently combining the data from the multi-pass scans to reconstruct 3D images of targets and measure their 3D acoustic frequency responses.

Significant challenges included compensating for spatial and temporal sound propagation speed variations, the complexity of the local seafloor and the 3D positioning uncertainties inherent to underwater navigation that complicated multiple pass synthetic aperture processing.

The results were impressive. Using relatively low frequency underwater sound waves, their techniques allowed video-quality figures to be produced. This work will generate an acoustic training database, enabling eventual use by commercial UXO survey contractors.

Resource Conservation and Resiliency SERDP Project of the Year

Deep Mapping of Teuthivorous Whales and Their Prey Fields

Dr. Kelly J. Benoit-Bird
Oregon State University
Monterey Bay Aquarium Research Institute

Recent research and development efforts have helped to greatly expand the understanding of both the behavior and biology of deep-diving marine mammals. There have been several studies of the physical habitat of these deep-diving predators but our understanding of the available prey, a key component in the biological habitat of these animals, is not as well developed. The main prey of these marine mammals are squid and they have proven to be difficult to study due to their rapid speed, relatively large size and depth range.

A SERDP-funded project led by Dr. Kelly J. Benoit-Bird from Oregon State University and the Monterey Bay Aquarium Research Institute and her team aimed to address this gap in research through the development of a new platform to carry the acoustic instruments needed to assess squid and then utilize the tool to understand the foraging ecology of deep-diving teuthivores (squid eaters). Study efforts targeted habitat used differentially by deep-diving, air-breathing predators (beaked whales and Risso's dolphins were chosen as the study subjects) to empirically sample their prey's distributions on and off a Navy testing range. Dual-frequency (38 and 120 kHz) split-beam echosounders were integrated into a REMUS 600 AUV, effectively doubling the

An improved understanding of marine mammal prey will help DoD better manage interactions with these creatures.

range of quantitative, multifrequency acoustic data into the mesopelagic zone (600 to 1,200 meters in depth).

Results of this project showed significant spatial variability in the size, composition, total biomass and spatial organization of biota over all spatial scales examined and was consistent with the general distribution patterns of foraging Cuvier's beaked whales observed in separate studies. Remarkable differences were found in prey characteristics between regions at depth, changes that were unobserved in surface layers. The revelation that animals deep in the water column are so spatially heterogeneous at scales from 10 meters to 50 kilometers critically affects the understanding of the processes driving predator-prey interactions, energy transfer, biogeochemical cycling and other ecological processes in the deep sea along with the connections between the productive surface mixed layer and the deep-water column.

The research team also explored the behavior of Risso's dolphins foraging in somewhat shallower scattering layers off Santa Catalina, California using a similar approach. Active acoustic measurements demonstrated that Risso's dolphins dove to discrete prey layers throughout the day and night with only slightly higher detection rates at night.

Dolphins were detected in all three layers during the day with over half of detections in the middle layer, 20 percent of detections in the deepest layer and 10 percent falling outside the main layers. Dolphins were found less frequently in areas where the shallow, intermittent layer was absent, suggesting that this layer, though containing the smallest prey and the lowest densities of squid, was an important component of their foraging strategy. The technology and approaches used in this project are already being transitioned to additional applications within the marine mammal community.

Weapons Systems and Platforms SERDP Project of the Year

Cyanate Ester Composite Resins Derived from Renewable Polyphenol Sources

Dr. Benjamin Harvey
Naval Air Warfare Center—Weapons Division (China Lake, California)

Carbon fiber polymer composites are important structural materials for weapon systems and aerospace platforms. They provide remarkable strength, reduced susceptibility to corrosion and significant weight reductions compared to aluminum. This allows for enhanced warfighter capability, reduced fuel usage and enhanced resistance to corrosion, thereby greatly reducing lifecycle costs.

Most thermosetting resins are synthesized from phenols that are generated from unsustainable petroleum sources by multi-step routes that are energy and solvent intensive. Further, many of the precursors to conventional thermosetting resins have estrogenic effects and toxicity issues. To address these environmental challenges while increasing the availability of sustainable, domestic sources for high temperature materials, Dr. Benjamin Harvey and his team from the Naval Air Warfare Center - Weapons Division (China Lake, California) developed new methods to efficiently convert bio-based feedstocks to polyphenols and thermosetting resins that in many cases outperform petroleum based materials.

A hydrophobic thermosetting resin generated from pine resin displays remarkable properties.

New thermosetting polymers have been prepared from vanillin and creosol—two molecules that can both be readily derived from lignin. In addition, a liquid, highly processable monomer has been derived from anethole, a significant component of pine resin and the essential oil of star anise. Another avenue of research has focused on the conversion of eugenol, the main component of clove oil, into thermosetting polymers, polycarbonates and homogenous network structures.

As a key example of the remarkable properties afforded by these bio-based materials, a hydrophobic polymer has been synthesized from pine resin that exhibits one of the lowest water uptakes ever measured for this class of materials and

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thermomechanical properties that are unaffected by exposure to boiling water for four days. This remarkable material has obvious applications for use in maritime environments.

In one of the most exciting and innovative facets of this work, biosynthetic phenols are being used as precursors to thermosetting polymers. In collaboration with industrial partners, the phenols are generated from biomass sugars via fermentation with metabolically engineered organisms. A key example of this technology is the development of a thermosetting resin from the trisphenol resveratrol. The derivative polymer has a glass transition temperature of 350 degree Celsius, a char yield in air of greater than 70 percent, and the lowest heat of combustion (2.5 kilojoules/gram) recorded to date for an organic polymer. Polymer composites prepared from resveratrol are of significant interest for missile cases, high temperature structural components and fire resistant coatings.

Several of the resins developed through this project have been incorporated into both flat panel laminates as well as bulk molding compounds (BMC) that can be fabricated into virtually any shape. Bio-based BMCs have been used to fabricate composite polar bosses (rocket case connectors) that are roughly half the weight of conventional aluminum polar bosses. The simple and efficient BMC fabrication process is expected to greatly reduce the cost and lead time of these components.

In addition to the remarkable material properties of the bio-based polymer composites, initial computational studies predict that many of the bio-based polyphenols will not bind to the estrogen receptor site making them safer to use for both thermosetting and thermoplastic polymer applications. Further, studies have shown that some of the bio-based thermosetting resins can be partially recycled by pyrolysis under humid conditions.

About SERDP & ESTCP

SERDP and ESTCP are DoD's environmental research programs, harnessing the latest science and technology to improve DoD's environmental performance, reduce costs and enhance and sustain mission capabilities. SERDP and ESTCP respond to environmental technology requirements common to all of the military Services, complementing the Services own research programs. The programs promote partnerships and collaboration among academia, industry, the military Services and other Federal agencies. Investments are managed in five program areas:

1. Energy and Water
2. Environmental Restoration
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms

SERDP and ESTCP are independent programs managed from a joint office to coordinate the full spectrum of efforts, from basic and applied research to field demonstration and validation.

SERDP is DoD's environmental science and technology program, planned and executed in partnership with the Department of Energy and the EPA, with participation by numerous other Federal and non-Federal organizations. The program focuses on cross-service requirements and pursues solutions to the Department's environmental challenges while enhancing and sustaining military readiness.

ESTCP is DoD's environmental technology demonstration and validation program. Project researchers conduct formal demonstrations at DoD facilities and sites in operational settings to document and validate improved performance and cost savings. Demonstration results are subject to rigorous technical reviews to ensure that the conclusions are accurate and well supported by data.

For more information, visit www.serdp-estcp.org.

Jeffrey Houff
SERDP and ESTCP Support Office
703-610-2709
Jeffrey.Houff@noblis.org